Artificial Intelligence for Classification of the Electrocardiogram

Lanng, Mathias Buus; Struijk, Johannes Jan; Graff, Claus

Publication date:
2019

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Mathias Buus Lanng*, Johannes J. Struijk*, Claus Graff*
*Department of Health Science and Technology, Aalborg University, Denmark
mbl@hst.aau.dk

CardioTech ResearchGroup

AALBORG UNIVERSITY DENMARK

Introduction

- The electrocardiogram (ECG) is a recording of the electrical activity of the heart which can be used to diagnose a patient.

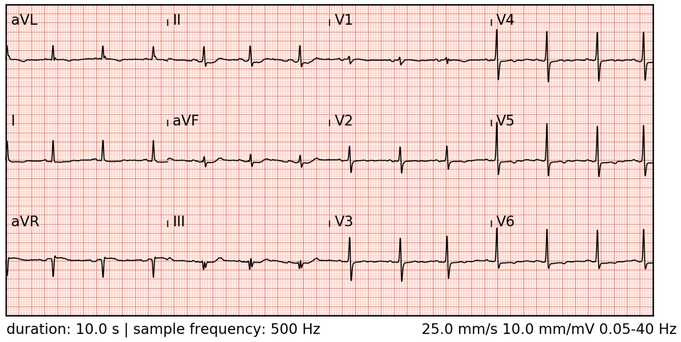

Fig. 1: A standard 12 lead, 10 second ECG

- Current automated algorithms for ECG diagnoses are rigid in making their diagnosis and binary[1]
- A regular classification neural network (NN) would be cumbersome to retrain if diagnoses change and more ECGs become available, along with being based on the distribution of the dataset it is trained on

Aim

- Make a classification algorithm based on NN that are more flexible to change in diagnoses, can seamlessly use new ECGs as they become available and better be used in other populations than what is trained on

Methods

- Train a Variational Autoencoder (VAE)[2] to compress the median heart beat into few but informative features and afterwards reconstructing it

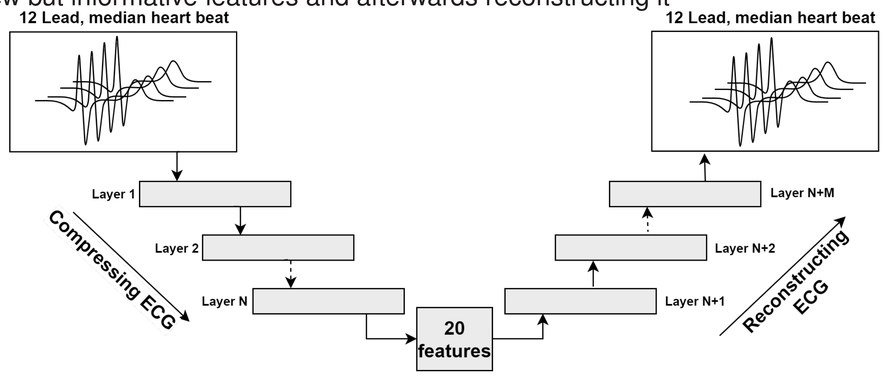

Fig. 2: Illustration of a VAE which compresses the median heart beat into 20 features and reconstructs it.

Methods cont.

- Use the features from the VAE to construct a point cloud of ECGs and use a nearest neighbour based algorithm to find the diagnosis of a new ECG.

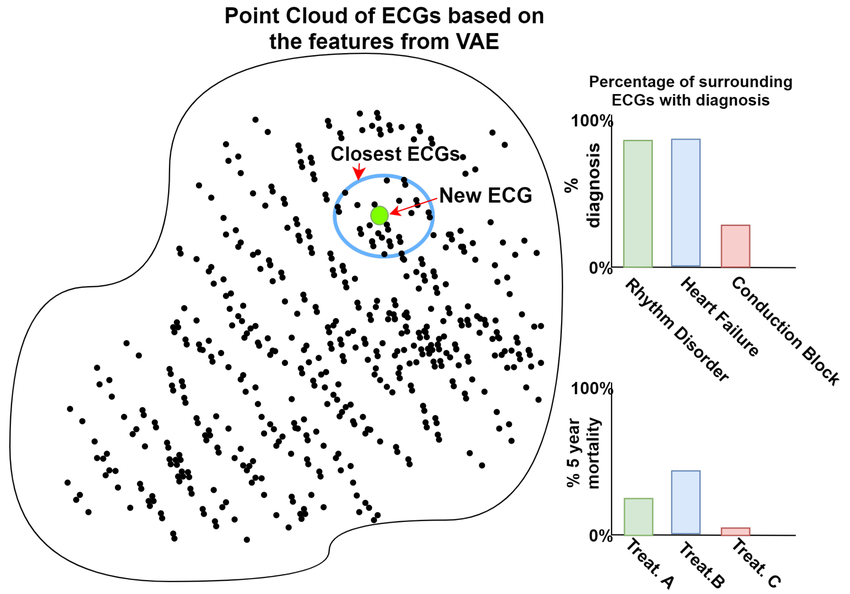

Fig. 3: Illustration of the algorithm used to make the diagnoses based on the features from the VAE

- This algorithm requires that the number of features are few and that they are linear in their impact on the reconstruction

Preliminary results

- Reconstruction of the medians is going very well, but the linearity of the latent features has not yet been analyzed

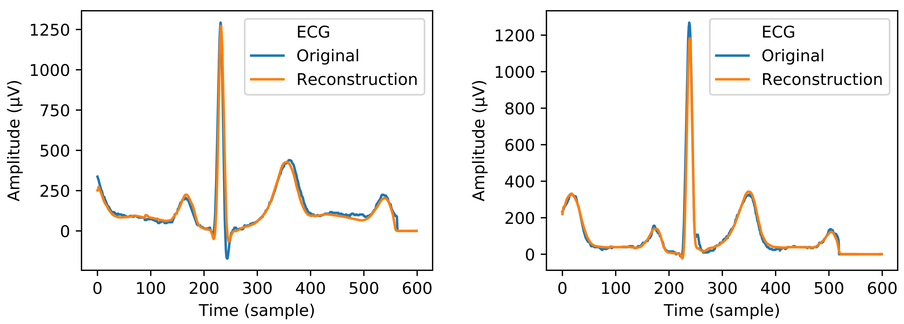

Fig. 4: Examples of two different reconstructions of the median

Discussion

- This algorithm has the advantage that
  - newer ECGs can easily become part of the point cloud and thereby contribute to further diagnoses
  - diagnoses can be changed by simply relabeling, no retraining required
  - other establishments can use their own ECGs and diagnoses to construct the point cloud
- The VAE ensures that the features are interpretable, which means that it is possible to take a real ECG and adjust the feature that encodes a diagnosis eg. "heart failure" to see what the ECG would look like with heart failure

Next Work

- Analyzing the feature space of the VAE to make sure that it is sufficiently linear in nature so the algorithm is feasible
- Analyze the features to find out which morphologies or diseases they encode in order to simulate different scenarios

References

[1] GE Healthcare. *Marquette^{TM} 12SL^{TM} ECG Analysis Program Physician's Guide*. 416781-004 Revision E. General Electric Company, 2008.

[2] D. P. Kingma and M. Welling. "Auto-Encoding Variational Bayes". English. In: arXiv.org, 2014.